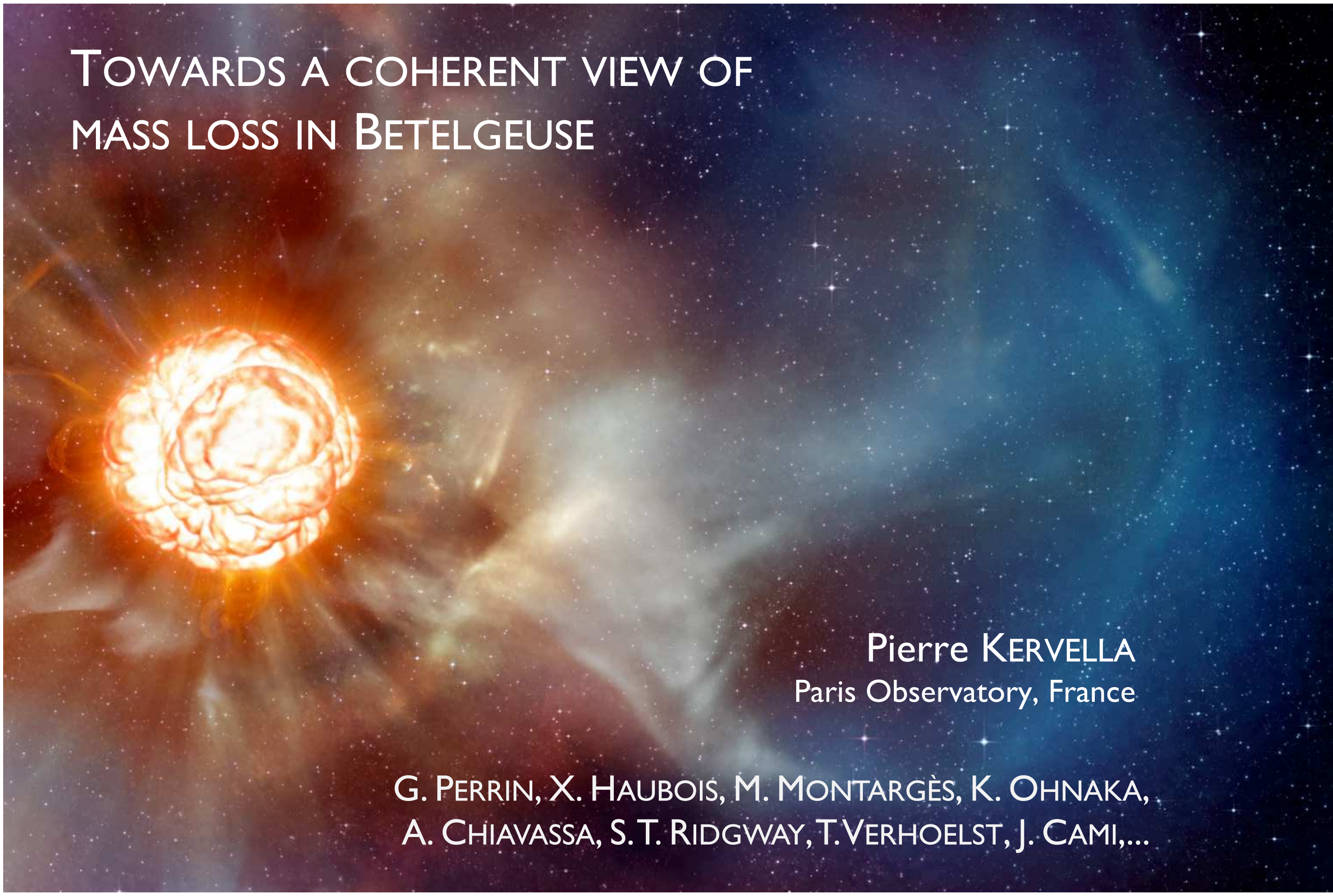

Towards a coherent view of mass loss in Betelgeuse

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Betelgeuse

- ~10-15 M_{sun}, T_{eff} ~ 3600 K, L > 100 000 L_{sun}
- R ~ 700 R_{sun}, angular diameter θ~45 mas
- Density ~ 40 mg/m^3 (Sun: 1400 kg/m^3)

Surface

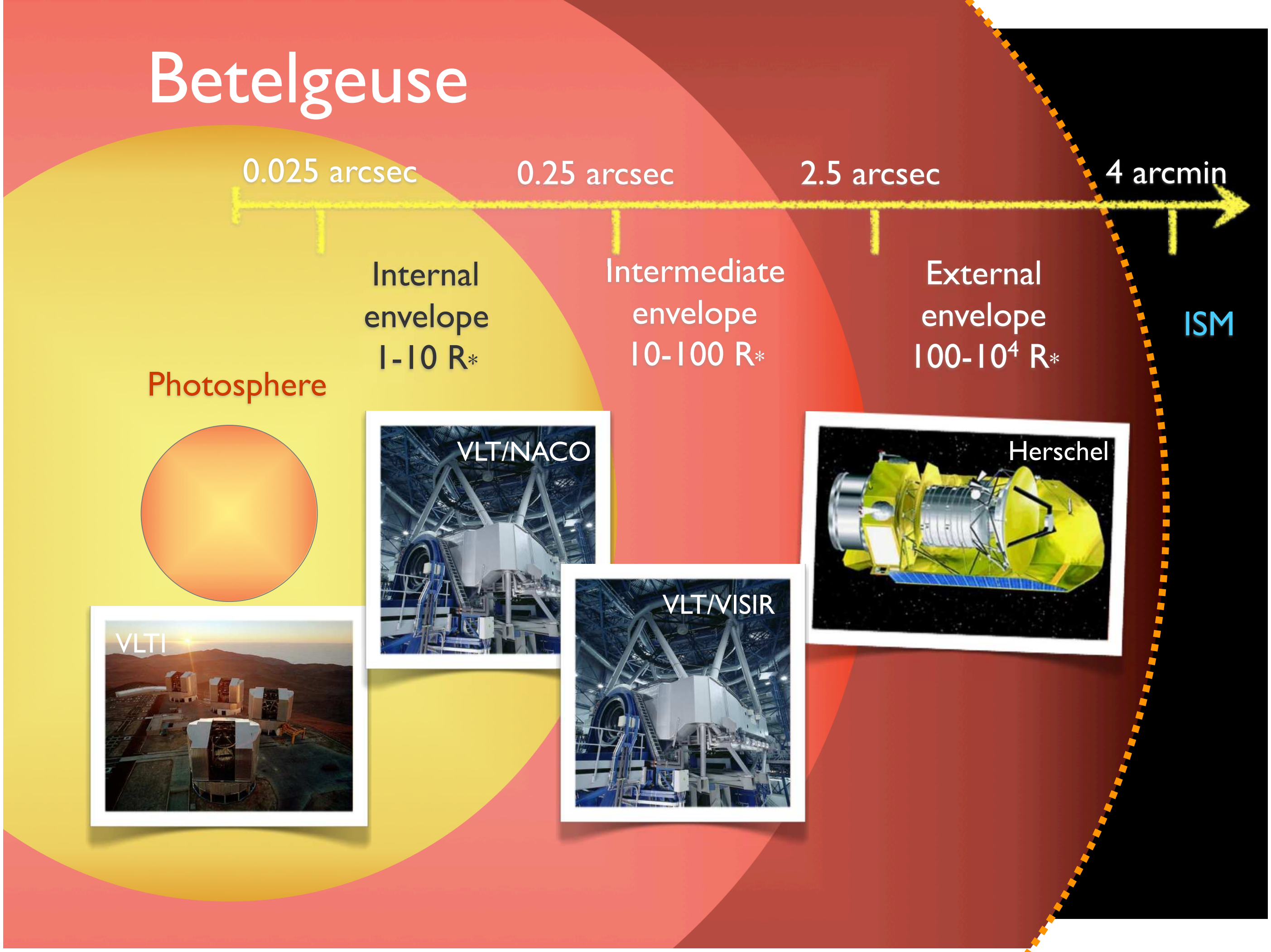
- What are the structure and properties of the convection ?

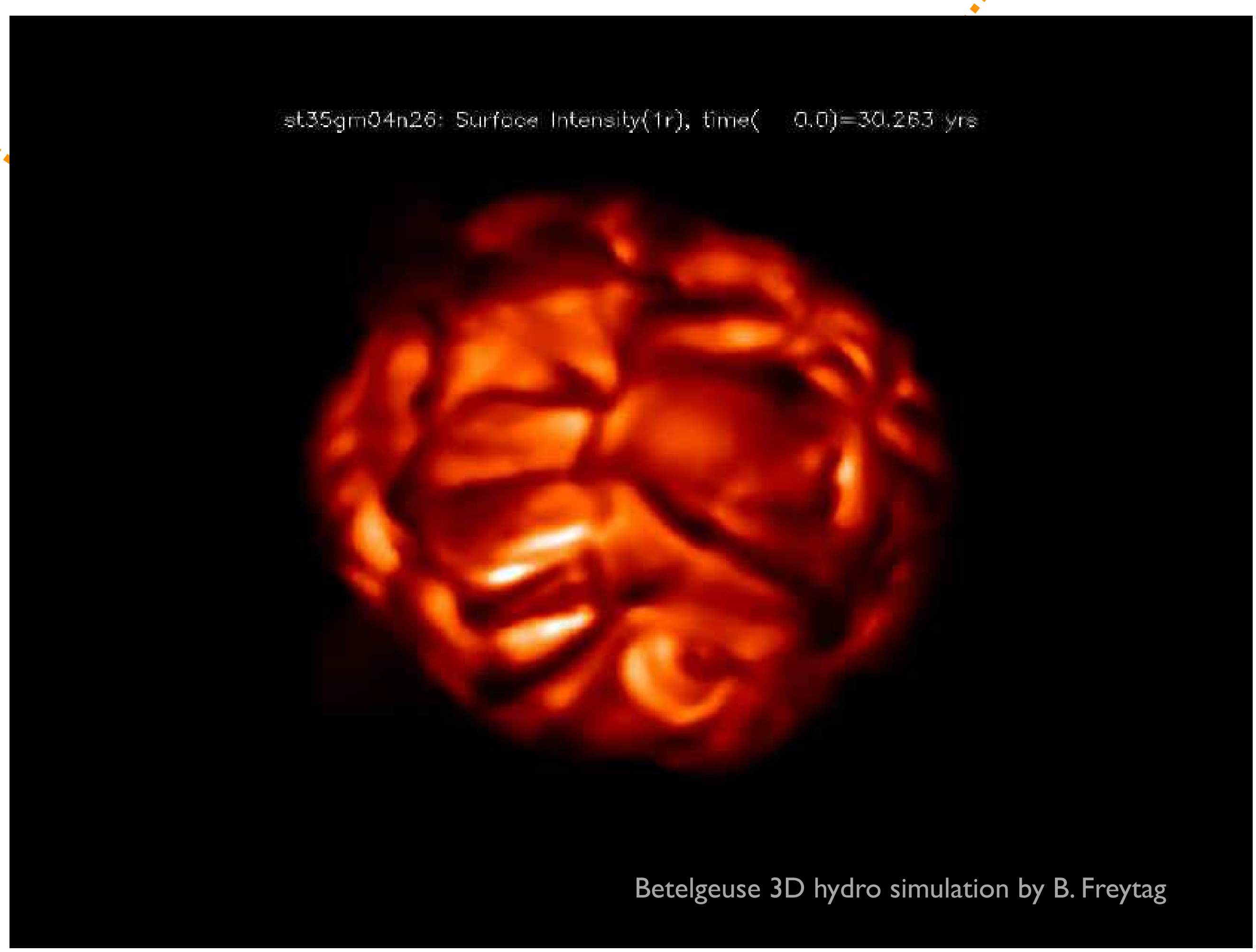
Envelope

- How does Betelgeuse loose its mass ? Dust-gas coupling in the envelope ?
- What is the structure of its envelope ? Molecular and dust chemistry ?

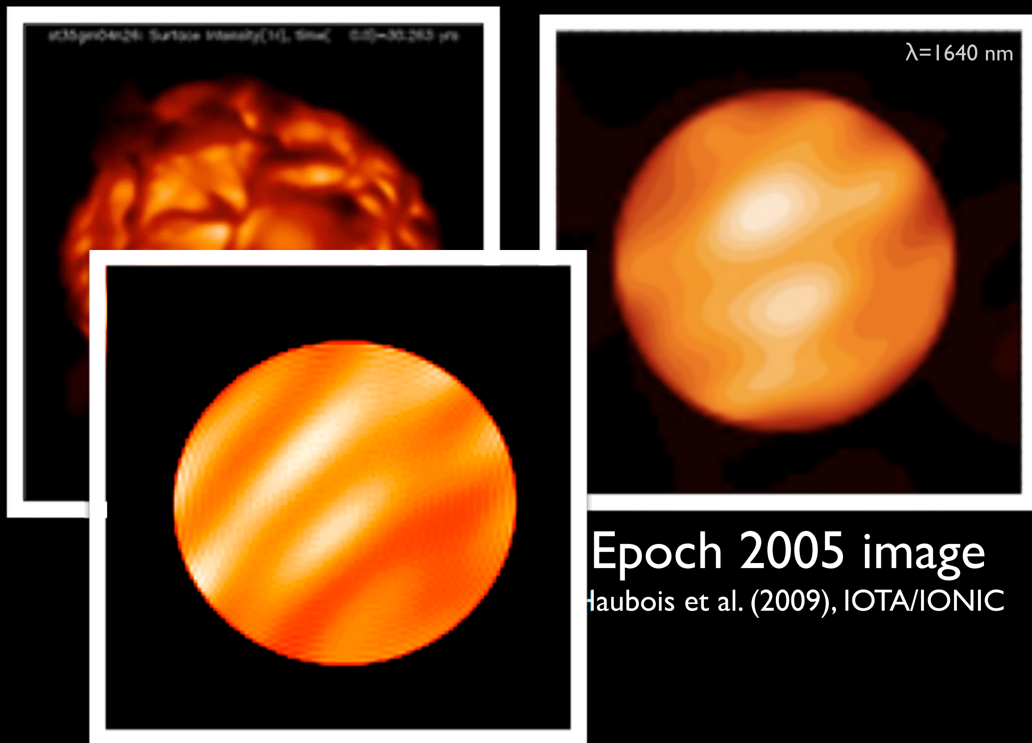
ISM

- How does the star interact with the interstellar medium ?





Betelgeuse 3D hydro simulation by B. Freytag



Epoch 2005 image

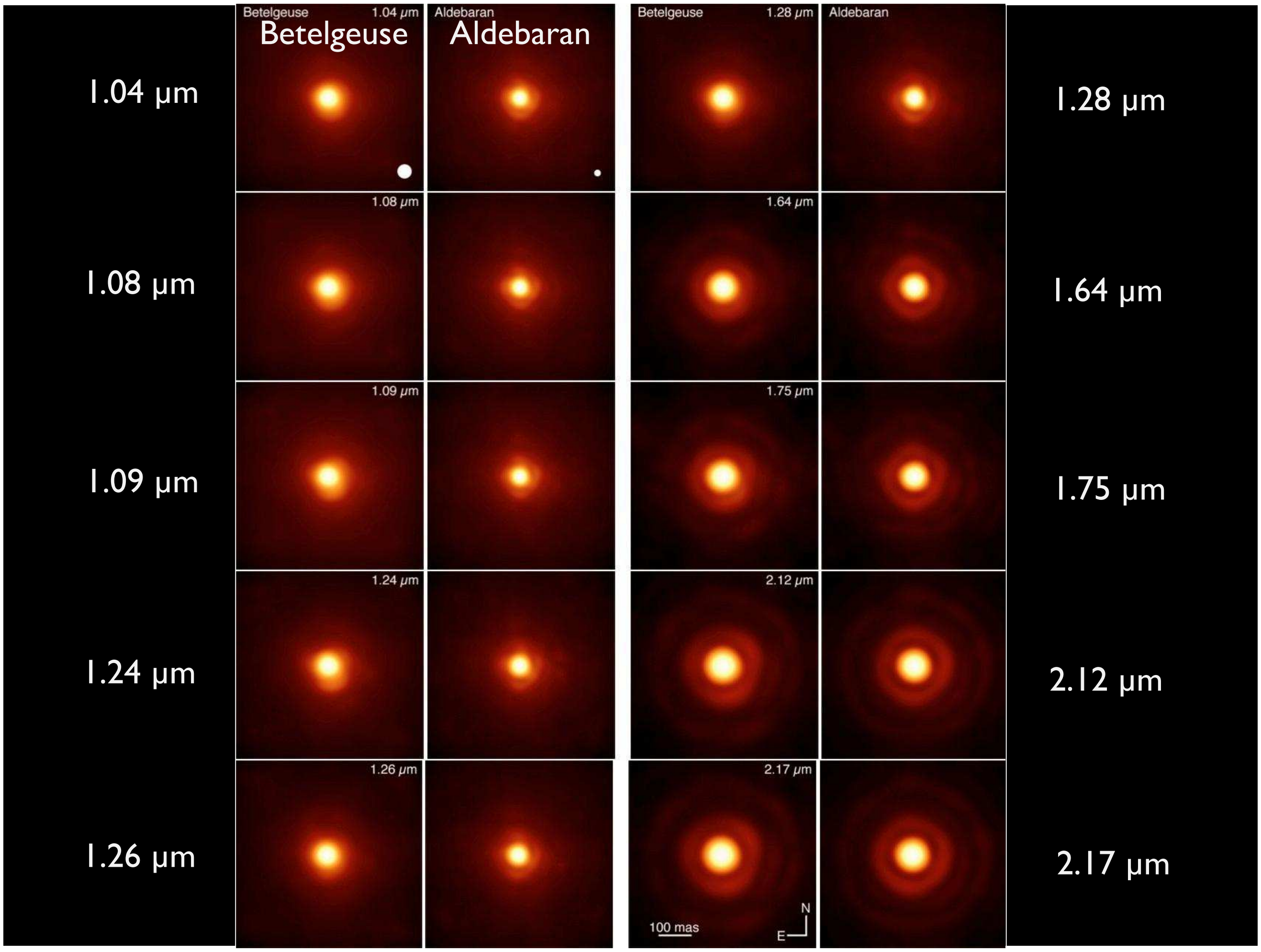
Haubois et al. (2009), IOTA/IONIC

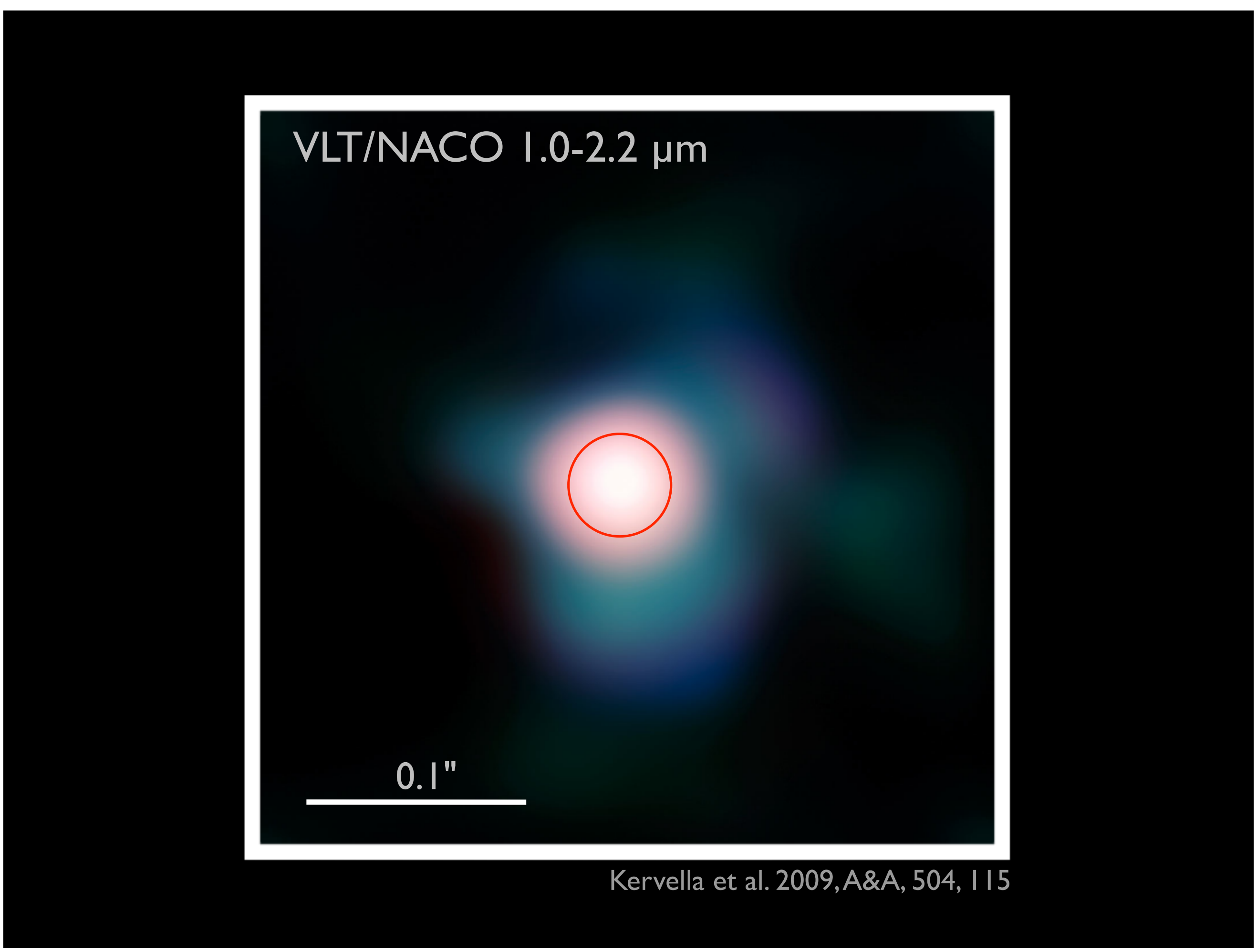
Preliminary 2012 image

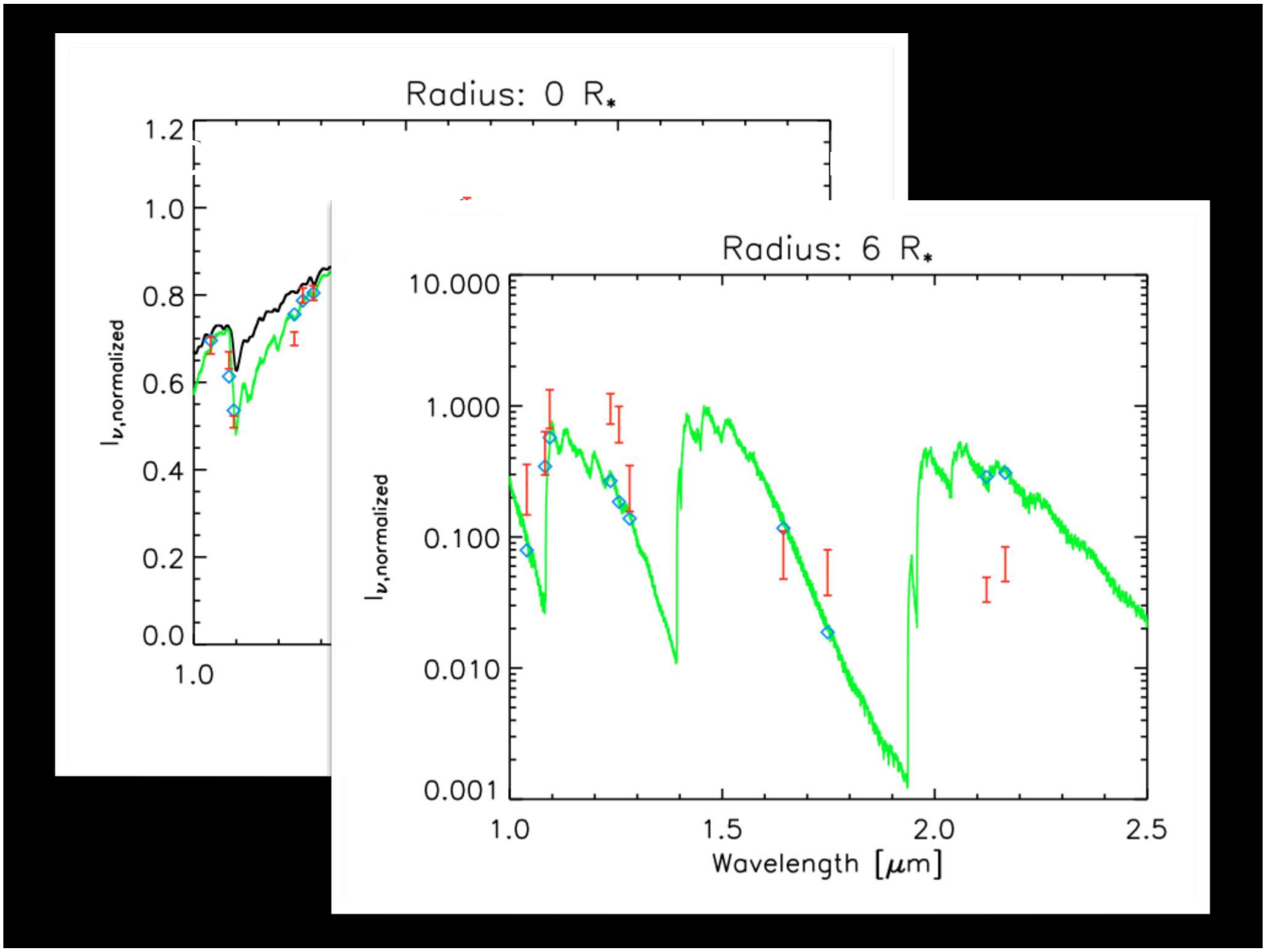
Kervella et al. (poster), VLTI/PIONIER

The internal envelope

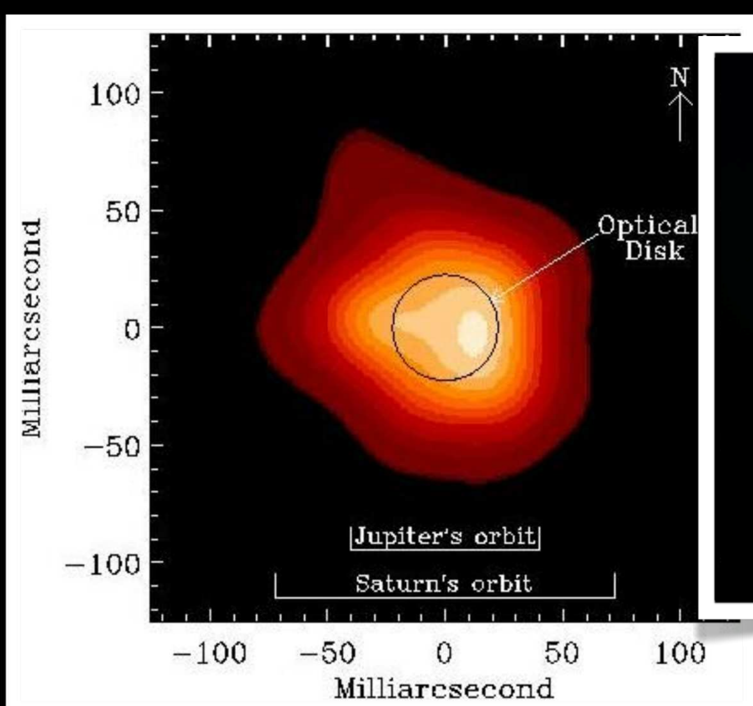
- Presence of molecules («MOLsphere»)
- Optical interferometers, large ground based telescopes or HST can resolve the internal envelope (θ~50-100 mas)
- Observations also feasible in the radio domain (VLA, IRAM, ALMA)
- Observations with VLT/NACO lucky imaging in 10 narrow-band filters (1.0-2.2 μm)

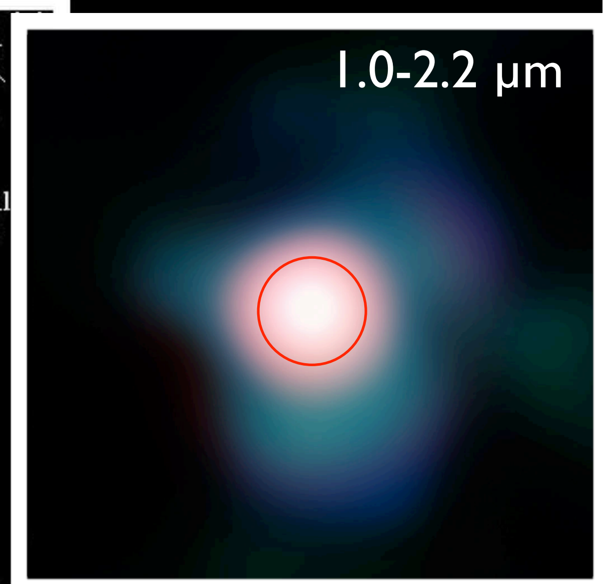

Betelgeuse
Aldebaran
1.04 µm
1.08 µm
1.09 µm
1.24 µm
1.26 µm
1.28 µm
1.64 µm
1.75 µm
2.12 µm
2.17 µm
100 mas
N
E


VLT/NACO 1.0-2.2 µm
0.1"
Kervella et al. 2009, A&A, 504, 115



VLA, λ = 7mm

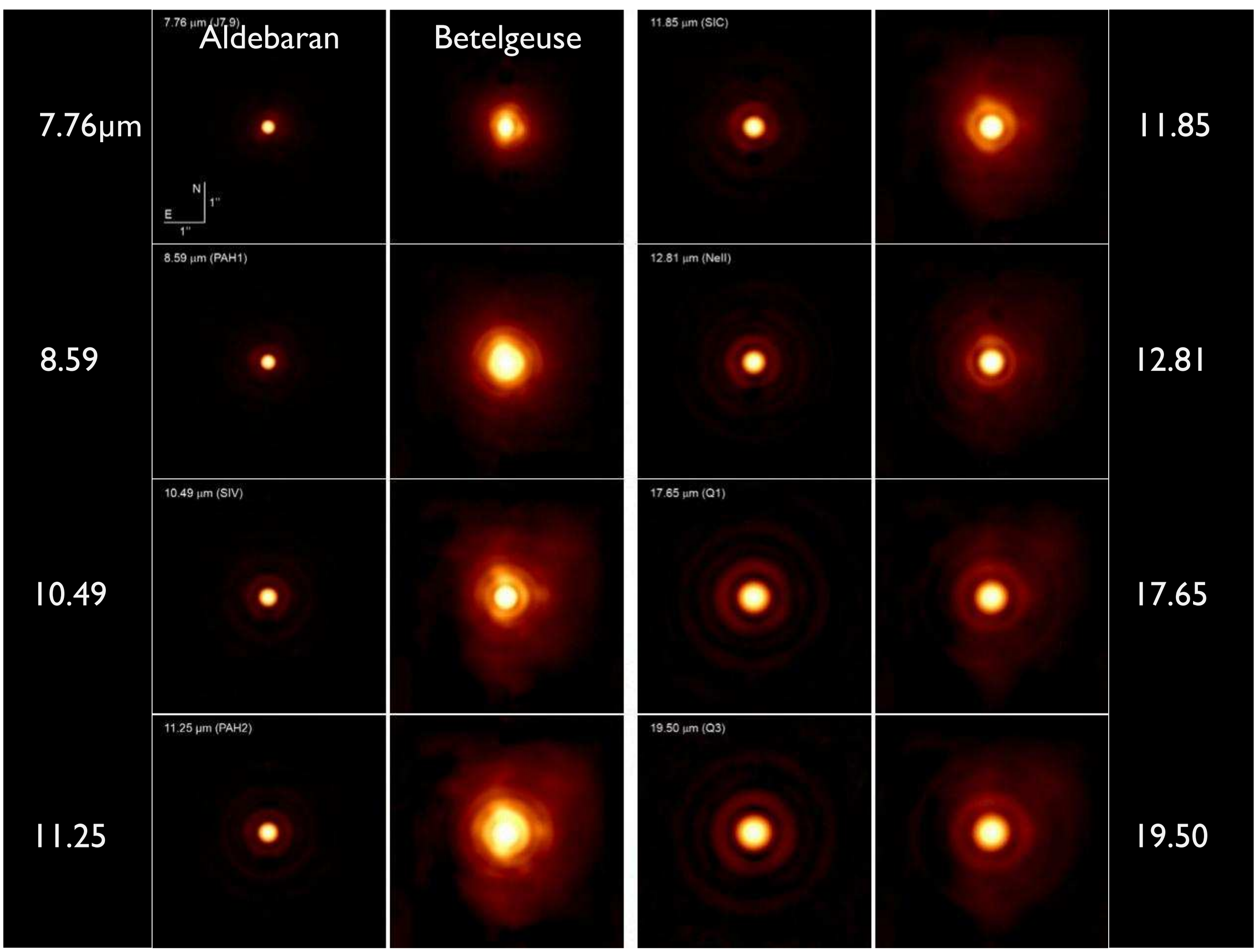


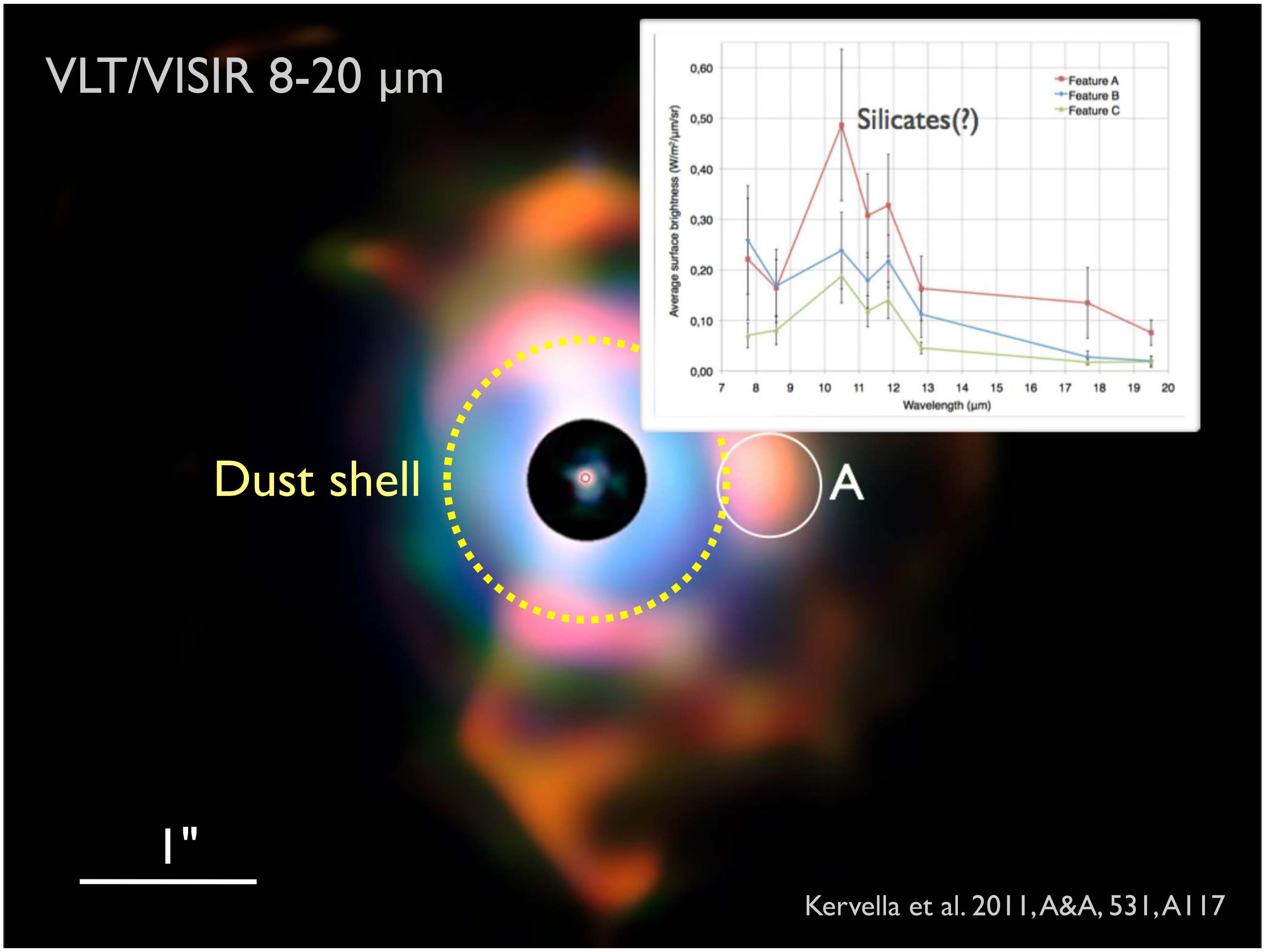


NRAO/AUI / Lim, Carilli et al. 1998, Nature, 392, 575

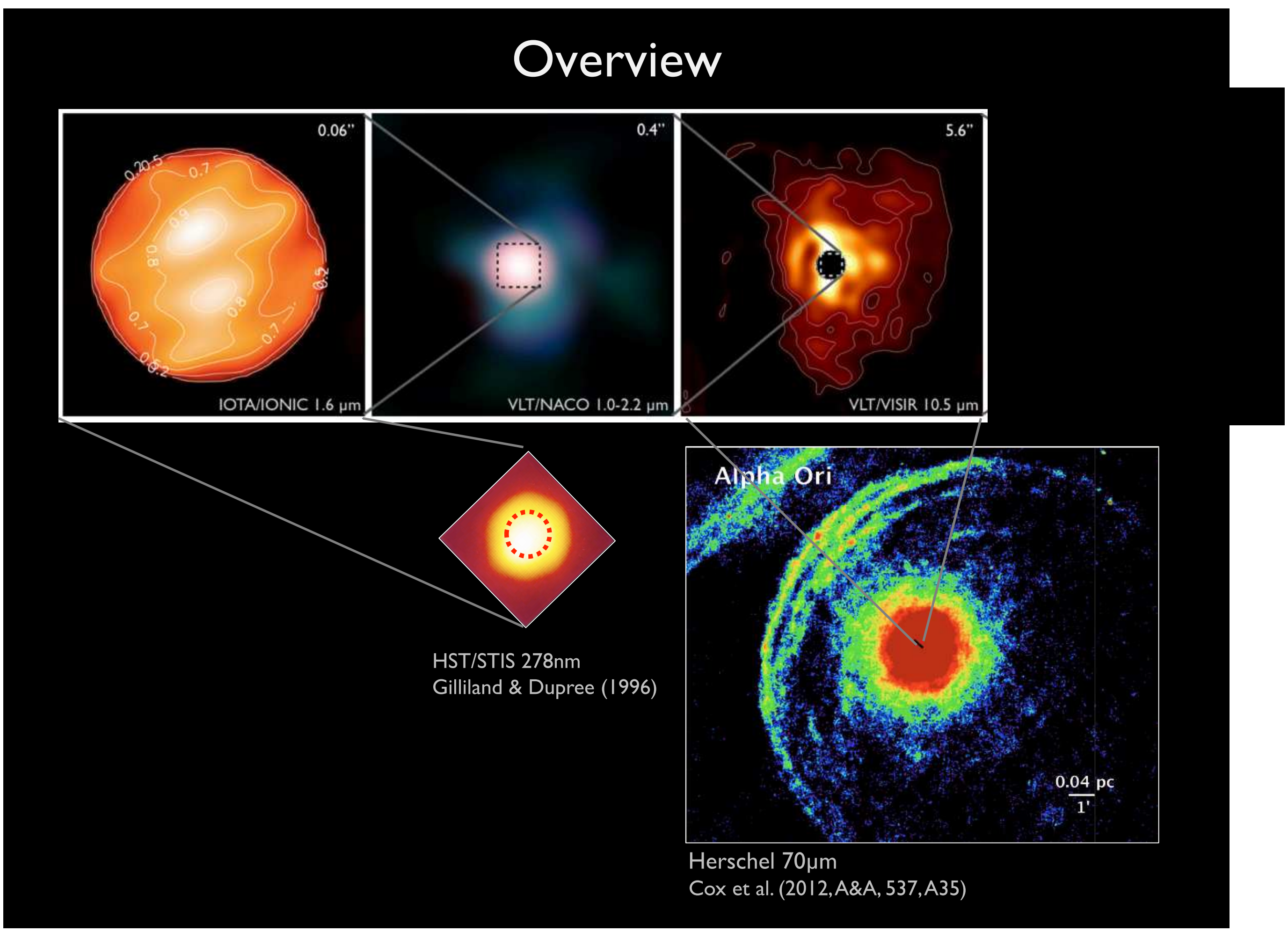
The intermediate envelope

- Main region for the formation of dust
- Observable in the thermal infrared domain and beyond
- Observations with VLT/VISIR lucky imaging between 8 and 20 μm in 8 filters





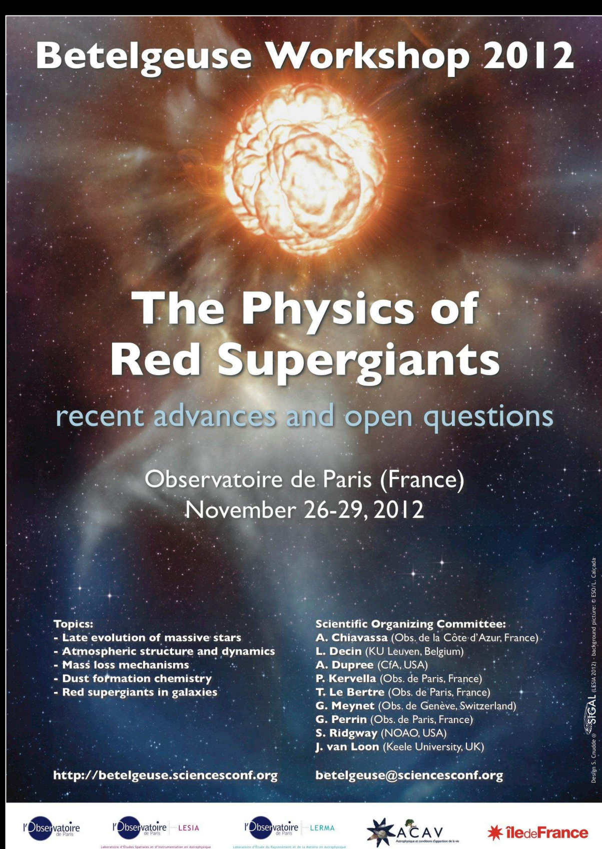
VLT/VISIR 8-20 μm
Silicates(?)
Feature A
Feature B
Feature C
Average surface brightness (W/m²/μm/sr)
0,60
0,50
0,40
0,30
0,20
0,10
0,00
7 8 9 10 11 12 13 14 15 16 17 18 19 20
Wavelength (μm)
Dust shell
A
1"
Kervella et al. 2011, A&A, 531, A117



Overview
0.06"
IOTA/IONIC 1.6 μm
0.4"
VLT/NACO 1.0-2.2 μm
5.6"
VLT/VISIR 10.5 μm
HST/STIS 278nm
Gilliland & Dupree (1996)
Alpha Ori
0.04 pc
1'
Herschel 70μm
Cox et al. (2012, A&A, 537, A35)

Conclusion

- From the photosphere to the ISM, several observing programs are in progress to renew our view of the mass loss of Betelgeuse
- Betelgeuse will be a prime target for the future instruments (e.g. ELTs), but beware of saturation !
- Thanks to its proximity and relative «simplicity», it is a fiducial star for the study of the final phases of the evolution of massive stars



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